Journal of International Money and Finance 130 (2023) 102752

Contents lists available at ScienceDirect

Journal of International Money and Finance

journal homepage: www.elsevier.com/locate/jimf

Central bank mandates: How differences can influence the content and tone of central bank communication

Martin T. Bohl [a], Dimitrios Kanelis [b,*], Pierre L. Siklos [c]

[a] Department of Economics, Westfälische Wilhelms-Universität Münster, Germany
[b] Department of Economics, Westfälische Wilhelms-Universität Münster, Am Stadtgraben 9, 48143 Münster, Germany
[c] Department of Economics, Wilfrid Laurier University, Balsillie School of International Affairs, and the Centre for Applied Macroeconomic Analysis (CAMA), Canada

ARTICLE INFO

Article history:
Available online 12 October 2022

JEL Classification:
E50
E52
E58

Keywords:
Expectations
Inflation
Central Bank Mandates
Speeches
Structural Topic Model
Unemployment

ABSTRACT

Using modern text mining methods, we analyze the influence of central bank mandates on the content and tone of communication via speeches. Relatedly, we also examine empirically how inflation and unemployment expectations affect the tone of speeches relative to past macroeconomic developments. We compare speeches given by senior officials of the Federal Reserve (FED) against ones of the European Central Bank (ECB). We find evidence that the mandate of the central bank does affect speech sentiment. That said, speeches by both central banks display greater similarities before the Great Financial Crisis (GFC), than afterwards. We also find that, especially since the GFC, unemployment expectations drive the tone of FED speeches while inflation expectations influence the tone of ECB speeches.

1. Introduction

Inflation, unemployment, and real economic conditions are among the key macroeconomic variables that influence decisions made by central banks. This is also true for the Federal Reserve (FED), which has a dual-mandate to ensure stable prices and maximize sustainable employment, and the European Central Bank (ECB), whose primary responsibility is to ensure price stability.

The last three decades in monetary policy can, for convenience, be divided into two parts. The 1990s and the early 2000s have been called the era of the Great Moderation (Bernanke, 2004). Then, near the end of the 2000s, the FED and the ECB faced financial crises. In the U.S., the legacy of newly created financial instruments in a deregulated financial system eventually led to the Great Financial Crisis (GFC) while the euro area would, shortly thereafter, experience a sovereign debt crisis. Economic conditions would deteriorate, and both central banks would be confronted with the zero lower bound (ZLB) and persistently low inflation rates. Indeed, the specter of secular stagnation (Summers, 2014) permeated the debate about how to conduct monetary policy in a low inflation and low economic growth environment. In response, the monetary policy toolkit of leading central banks expanded. Instead of relying primarily on policy rates, central banks implemented large-scale asset purchase programs and provided more verbal guidance about the future course of interest rates. Central banks

* Corresponding author.
E-mail address: Dimitrios.Kanelis@wiwi.uni-muenster.de (D. Kanelis).

https://doi.org/10.1016/j.jimonfin.2022.102752
0261-5606/

came to the realization that communicating the stance of monetary policy is critical and set out, gradually, to improve what and how much was said in public.

One goal of central banks is to ensure that expectations would be anchored to explicit inflation objectives (Woodford, 2003). Another goal was to improve the public's understanding of the objectives and limitations of monetary policy. Nevertheless, even as the GFC was underway, central banks still had much to learn about delivering effective communication (Blinder et al., 2008). By the time the pandemic of 2020 arrived, both central banks underwent strategy reviews during a period that brought new challenges to the conduct of monetary policy (Orphanides, 2021).

The completed strategy reviews of the Federal Reserve System (2020) and the European Central Bank (2021a) provide another occasion to revisit the role of communication during the last two decades. Research on central bank communication suggests that speeches are a critical vehicle to convey monetary policy aims and objectives to the public. In contrast to press conferences held by the FED chair and ECB president, individual members of the policy-making committee communicate directly to the public via speeches. Central bankers use speeches to communicate their institution's intellectual development and learning processes, such as during the European sovereign debt crisis (ESDC) (Ferrara, 2020). More importantly, speeches represent an instrument that can illuminate how a central banker's views are influenced or constrained by the mandate given to the monetary authority.

Generally, analyses of central bank communication via speeches focus on the general thrust of the messages that are conveyed to the general public. Furthermore, the literature highlights the important role of expectations, next to observed developments, when analyzing various central bank publications (Shapiro and Wilson, 2021). In contrast, the variables that lie at the core of many central banks mandates, namely inflation and unemployment, are generally not separately examined from the standpoint of whether and how they drive the content and tone of speeches, leaving some interesting unanswered questions for researchers to explore.

In this paper, we ask: how do economic objectives spelled out in central bank mandates affect the content and tone of speeches? Do differences exist between a dual-mandate and a single-mandate central bank? Furthermore, how do expectations about inflation and unemployment affect the tone of speeches relative to past economic performance? To do so, we compare speeches delivered by senior officials at the FED and the ECB.

We first construct a new data set consisting of speeches from the FED Board of Governors from mid-1996 until March 2021 and all speeches from the ECB Executive Board from the introduction of the Euro in 1999 until the end of 2020. Using text mining and Structural Topic Models (STM; Roberts et al. (2016)), we classify every speech according to the underlying topic and display their development over time. We find that the ECB's Executive Board focuses more on inflation and unconventional monetary policy than on employment issues in the years after the GFC. In contrast, the FED's Board of Governors tends to focus on employment and labor market conditions. FED Governors talk less about long-term supply-side behavior and devote more attention to aggregate demand conditions.

Next, we zero in on the speeches that address central bank mandates and quantify the tone of each speech using the new dictionary of Apel et al. (2019). Using tone as a dependent variable, we show that expectations about the economic variables at the center of each central bank mandate significantly drive the tone of speeches. The relationship is visible in FED and ECB speeches since the GFC, and our results are insensitive to several robustness checks. Furthermore, our comparison of the FED and the ECB reveals significant qualitative differences between the dual and single-mandate regimes regarding the tone of speeches, at least since the GFC. While inflation expectations influence the tone of speeches of ECB Executive Board members, consistent with their mandate, unemployment expectations shape the tone of speeches by members of the FED's Board of Governors, with inflation playing a lesser role.

This study contributes to the existing literature by systematically analyzing the role of economic variables that define the mandates of the FED and the ECB and how they are reflected in speeches delivered by members of their respective policy-making committee. We use topic modeling to disentangle the different messages conveyed by central bankers. Equally important, our study suggests that focusing on specific topics may be more effective in helping us to understand the conduct of monetary policy than considering the whole corpus of speeches. Especially, when analyzing how economic developments influence some of the most important elements of central bank communication.

The remainder of this study is structured as follows. After providing a brief literature review in Section 2, Section 3 briefly describes the macroeconomic background of both economies, the data set and how we use the STM methodology to classify all speeches according to the underlying topic covered. Section 4 provides a broad investigation of how central bankers address the objectives of their mandate from a long-term perspective. In Section 5, we present our model to analyze how mandates influence the tone of speeches. In Sections 6 and 7, we provide results and robustness checks. The final section concludes.

2. Related literature

The increase in emphasis on central bank communication since the new millennium significantly shifted research on monetary policy (Blinder et al. (2008),Bholat et al. (2015)). An often-mentioned motivation for improvements in communication stems from inflation targeting. Indeed, this development is also reflected in the rise in central bank transparency over the past two decades (e.g., see Dincer et al. (2019)), which emphasizes that clear and coherent communication is necessary to

manage inflation expectations effectively. In what follows, we provide only a highly selective overview of the relevant research, which has expanded considerably in recent years.

One of the expanding branches of the literature studies communication channels to understand central bankers' developing intentions and learning processes. Shapiro and Wilson (2021) use the transcripts of Federal Open Market Committee (FOMC) meetings to quantify the "true" loss function and inflation target of the FOMC. They measure the sentiment of individual FOMC members using the dictionary of Loughran and McDonald (2011) and regress the sentiment on macroeconomic variables. For the 2000–2011 period, Shapiro and Wilson (2021) identify a "true" inflation goal of 1.5%, which is lower than the announced 2% inflation target. Analogously, Paloviita et al. (2020) assess the preferences of the ECB council by analyzing ECB press conference statements and estimate a "true" inflation target of 1.7%. Hansen et al. (2018) use the quasi-natural experiment that the FOMC transcripts before 1993 were not released and provide evidence that career concerns influence deliberations and how policymakers react under transparency. Dybowski and Kempa (2020) demonstrate the changing relevance of the monetary analysis by relying on ECB press conference statements.

Speeches are a particular means of communication for central banks, as central bankers can communicate more freely while generally retaining the ability to choose the speech topic. Bohl and Siklos (2007) were among the early contributors in analyzing speeches delivered by Bundesbank officials based on a classification of topics developed by the Bundesbank. Benanni and Neuenkirch (2017) create a dictionary to measure the hawkish- or dovishness of speeches by ECB Governing Council members. They conclude that the tone varies depending on whether a governing council member is speaking domestically or abroad, motivating Benanni and Neuenkirch (2017) to call it the "home bias." The degree of central bank independence before the introduction of the euro also influences the tone of speeches given by national central bank presidents of the Eurosystem. Moschella and Pinto (2019) demonstrate how concerns about the reputation of the FED affect the topic selection of speeches by Board of Governor members. Analogously, Moschella et al. (2020) provide evidence that the satisfaction of the euro area citizens with the ECB affects the topic selection of speeches by Executive Board members.

Ferrara and Angino (2021) provide evidence that (social) media engagement with the ECB increases when senior officials use less complicated language when communicating to the public. The study not only provides evidence of how to improve communication with the public, but it is part of a growing literature on central bank accountability. For example, Ferrara et al. (2021) and Schonhardt-Bailey et al. (2022) analyze the content and discussions in parliamentary hearings about leading central banks and provide evidence that accountability vis-á-vis the central bank's mandate is affected by the interests of parliamentarians' constituencies. Blinder et al. (2022) provide a literature survey on communication with the broader public and argue that central banks have difficulty reaching the public and this remains an important challenge for the future.

3. Macroeconomic background and topic identification

3.1. Macroeconomic background

Comparing the inflation rate in the U.S. and the euro area, we identify three periods, highlighted by the ellipses in the upper panel of Fig. (1), during which inflation behaves differently in the U.S. and the euro area regarding the direction of change or the level. Except for the pandemic and the two years following the 2001 dot-com bubble, inflation in both jurisdictions has been similar. In the aftermath of the ESDC, inflation in both economies is well below target but more volatile in the U.S. than in the euro area.[1]

Looking at the unemployment data, broad similarities regarding changes in the unemployment rate in both economies are visible, despite the level deviations due to differences in labor market institutions and support programs between the two economies.[2] During two periods, highlighted by the ellipses in the lower panel of Fig. (1), we observe a convergence in unemployment rates, though in the latter case, the U.S. unemployment rate also shows a brief and sharp rise which happened during the pandemic. The ESDC is the only period when unemployment rates in both economies diverge significantly. That said, changes in the levels are similar in both economies.

Given the comparable economic environment in both jurisdictions, it is plausible that differences in central bank mandates are reflected in how both central banks communicate.

[1] Inflation is less than 2% in the U.S. (euro area) almost 60% (55%) of the time covered by this study. The inflation objective was "below 2%" between 1999 and 2003 and then "below, but close to, 2% over the medium term" in the euro area (European Central Bank, 2021b). Before 2012, there was no formal inflation objective in the case of the FED, though it was generally considered to be 2% over the medium term (Bernanke, 2022). Inflation persistence is also similar in both economies. A common way of estimating the persistence of inflation is to estimate a first-order autoregressive (AR1) model. The AR1 coefficient (standard errors in parenthesis) is 0.97 (0.02) for the euro area and 0.96 (0.02) for the U.S. Given the standard errors shown in parenthesis, the degree of inflation persistence in both economies is, statistically speaking, the same. Including dummies for the three periods highlighted in the figure does not change the results significantly.

[2] Mean unemployment rates in the two jurisdictions are as follows (standard deviations in parenthesis): 9.37% (1.32) in the euro area and 5.8% (1.88) in the U.S.

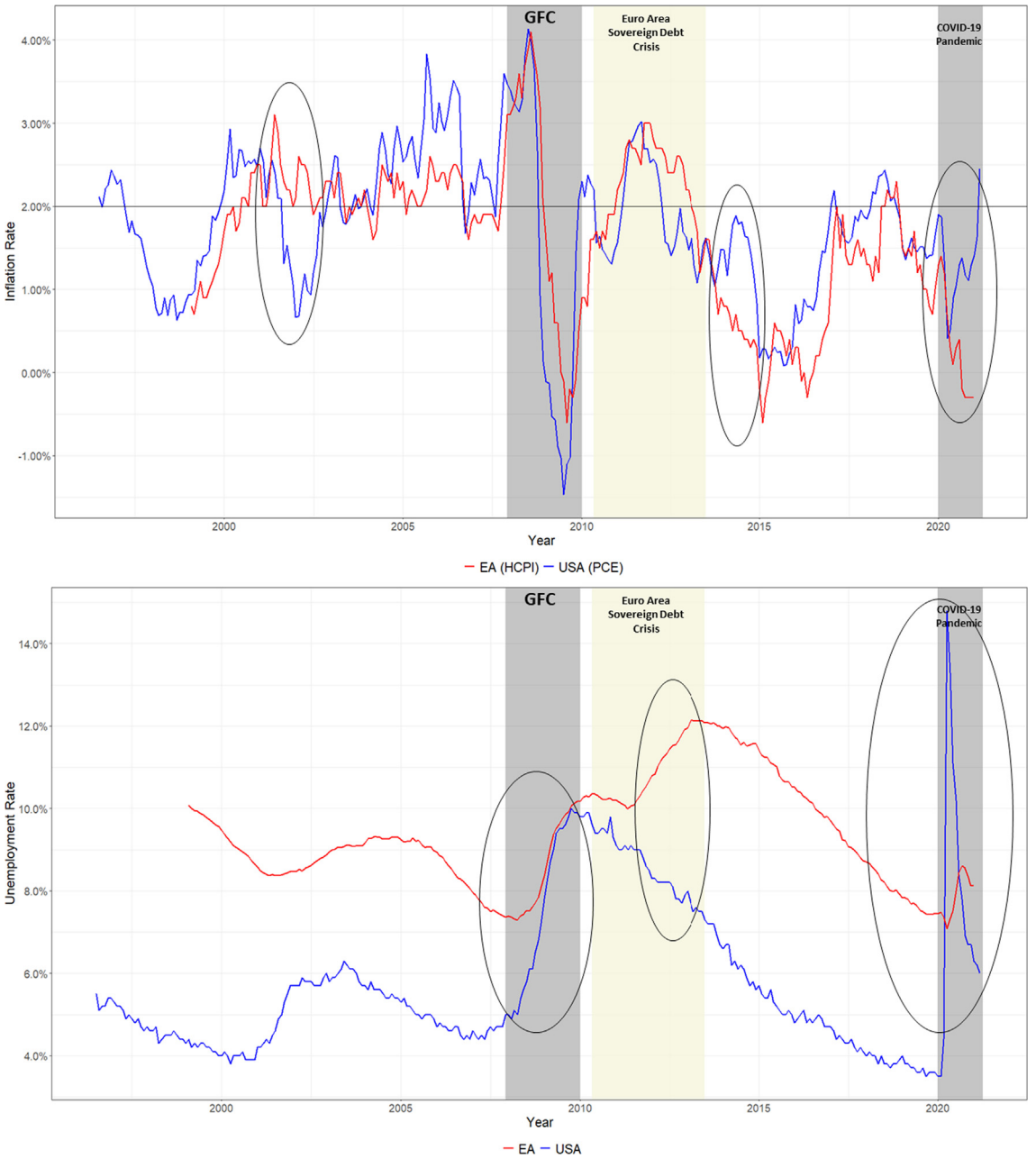

Fig. 1. Inflation and Unemployment in the U.S. and euro area (EA) Note: Inflation is annualized percent change in HICP (euro area) and PCE (U.S.). We use the monthly harmonized unemployment rate (euro area) and the civilian unemployment rate (U.S.). Shaded areas are defined in Section 5. **Source**: FRED Economic Data and ECB Data Warehouse.

3.2. Textual data

We construct a data set consisting of all speeches of the FED Board of Governors and the ECB Executive Board. The European Central Bank (2019) provides all speeches from the Executive Board members on their website.[3] Speeches of the FED Board of Governors from 2006 onward are available on the Board of Governors website (Federal Reserve System, 2021),[4] while speeches before 2006 are available in the archives of the Federal Reserve System (2016).[5] We use only speeches

[3] https://www.ecb.europa.eu/press/key/html/downloads.en.html (Last Access: July 12, 2021)
[4] https://www.federalreserve.gov/newsevents/speeches.htm (Last Access: July 12, 2021)
[5] https://www.federalreserve.gov/newsevents/speech/2005speech.htm (Last Access: July 12, 2021)

from members of the FED Board of Governors or the ECB Executive Board and remove speeches without text.[6] Furthermore, we exclude all speeches by ECB Executive Board members not provided in English.[7]

One difference between the FED Board of Governors and the ECB Executive Board is reflected in the distribution of speeches between the head of the policy-making committee and the other members.[8] The ratio of speeches between the chair and committee members is higher for the Board of Governors than for the Executive Board. Furthermore, the number of speeches during the 2000s and the 2010s given by members of the Board of Governors declined from 878 to 596. In contrast, Executive Board members' speeches increased from 879 to 1113.

3.3. Classification method

To identify the underlying topics of central bank speeches, we use the STM methodology, an unsupervised machine learning model developed by Roberts et al. (2016). The STM defines topics from a mixture of words from the corpus of documents based on the probability that the words appear in a text. Each document consists of several topics, where our model assigns the document to the topic with the highest probability. In contrast to other topic modeling approaches, such as Latent Dirichlet Allocation (Blei et al., 2003), STM uses a correlated topical model structure and includes document metadata as covariates. We use a dummy variable that equals one if the speaker is the chair of the FED or the president of the ECB to separately identify these speakers from the rest of the respective policy-making committee members. Furthermore, we include a dummy variable for each committee speaker to account for the fact that the policy-making committees assign specific tasks to each member, which may spillover into the content of their speeches.[9]

To estimate the STM on our two corpora of speeches, we first need to follow certain preprocessing steps: remove the bibliography and references, convert all letters to lower case letters, exclude punctuation and stop words, and reduce the words to their word stem. Furthermore, following Ferrara et al. (2021), we exclude every word in each speech with a term frequency lower than two. This last step increases the classification precision of the STM by removing words without content that do not necessarily belong to the typical list of stop words. Our corpus consists of 1824 speeches from the FED Board of Governors with 585054 words and 2165 speeches from the ECB Executive Board containing 450683 words after removing all words with a term frequency strictly lower than two.[10]

In the next step, the user has to choose the number of topics, K, identified by the STM algorithm. In this context, a higher K leads to more concrete topics. However, there is no known optimal choice for the value of K. Therefore, we follow the approach of Roberts et al. (2019) and focus on topic exclusivity (Bischof and Airoldi, 2012) and semantic coherence (Mimno et al., 2011). Topic exclusivity and semantic coherence lead to a trade-off since the first increases with a higher K while the latter decreases. We first estimate STM with $K \in \{4, \ldots, 60\}$ and calculate topic exclusivity and semantic coherence for each STM.[11]

4. How mandates affect the content of speeches

In this section, we use our STM methodology to focus on the topics related to the mandates of the FED and ECB to analyze the differences in communication between a single-mandate and a dual-mandate central bank. The main takeaway is that differences between the dual-mandate and single-mandate manifest themselves in the content of speeches about monetary policy, especially after the GFC. FED Governors increasingly discuss unemployment, while ECB Executive Board members barely mention labor market issues and focus on price stability.

4.1. Dual mandate: FED board of governors

Having identified a Pareto efficient set of STM, we have to choose a specific K.[12] We base our decision on the interpretability of the underlying topics. For our descriptive analysis of Board of Governors communication, we choose $K = 10$, though the

[6] Some "speeches" merely provide presentation slides without any text.

[7] Using translated non-English speeches creates the risk of mistranslating essential words. Furthermore, excluding non-English speeches reduces the "home bias" of European central bankers adjusting to the preferences of a national public (Benanni and Neuenkirch, 2017).

[8] In the Appendix, we report the number of speeches of each FED Governor from mid-June 1996 until March 2021 and the number of speeches of each Executive Board member from January 1999 until the end of 2020 that we use in the sample.

[9] Roberts et al. (2016) illustrate the data generating process for the STM (see Appendix). Only the 'observed words' and the covariates which comprise the metadata are observable. The model algorithm infers the topic word distribution, the document-topic proportions, and the per-word topic assignment that incorporates the latent structure (Dybowski and Kempa (2020),Roberts et al. (2016)).

[10] These numbers consider each word once per speech to illustrate the word diversity of each policy-making committee. We provide descriptive statistics of the corpora in the Appendix.

[11] The Appendix illustrate the average values for semantic coherence and topic exclusivity for the Pareto efficient set of topics for each policy-making committee. We choose the topic models in the quadrant at the upper right corner (Ferrara et al., 2021).

[12] This means choosing a specific number of topics. Unfortunately, the literature cannot yet provide guidance that would lead to the choice of an optimal number. Too many topics reduce speeches' interpretability and their association with a central bank's mandate. Too few topics and there is a risk of identifying the content of speeches too imprecisely by combining too many topics. In what follows, we follow the practice adopted in several studies and choose a reasonable value for K and then determine how sensitive our results are to the alternative values of K.

selection of K does not affect our results (see Section 7). The relevance of each word is measured by its beta value, while the gamma value is the probability that a speech is associated with its affiliated topic (Roberts et al., 2019).[13]

From the ten topics identified, we identify four topics that are associated with keywords and content that relate to inflation and unemployment and, therefore, to the mandate of the FED: topic two "*Globalization, Growth, and Technology,*" topic four "*Stabilization Policy,*" topic eight "*Monetary Policy Implementation,*" and topic ten "*Community Development*".[14] The upper part of Fig. (2) shows the evolution of mandate-related topics in speeches for the Board of Governors over time.[15]

During the last ten years of Greenspan's chairmanship (1996–2006), Governors mention inflation, especially in speeches about "*Monetary Policy Implementation,*" (topic 8), where they discuss monetary policy strategies to ensure price stability (for example, Ferguson Jr. (1999), Gramlich (2003), Bernanke (2003))[16], the increasing relevance of central bank communication (for example, Bernanke (2004b)), and different challenges for monetary policy (for example, Bernanke (2004a)). When discussing the real economy in speeches about "*Stabilization Policy*" (topic 4), FED Governors include explanations and discussions about the relevance of monetary policies for short-run business cycle stabilization (for example, Kohn (2003), Bernanke (2005)).

Governors also discuss employment issues from a longer-term, structural point of view, focusing on the effects of globalization and the development of productivity growth in the U.S. (for example, Ferguson Jr. (2004), Bernanke (2004c), Kroszner (2006)). In particular, Greenspan, and Bernanke once he became FOMC chair in 2006, discuss employment issues from a non-monetary perspective.[17] The speeches of the members of the Board of Governors during the chairmanship of Greenspan, and the first two years of Bernanke's chairmanship, provide evidence for the observation that, until the onset of the GFC of 2008/2009, the FED interprets and communicates that price stability automatically creates the optimal environment for full employment. Without stable prices, markets could not work efficiently, leading to inefficient labor market allocation (Orphanides, 2019).

Not surprisingly, the GFC represents a break in the content composition of the corpus. As visible in Fig. (2), the topic "*Globalization, Growth, and Technology*" (topic 2) practically disappears. The relevance of the topic "*Monetary Policy Implementation*" remains similar, while the topic "*Stabilization Policy*" gains in importance. Governors address, in these speeches, the implementation of unconventional monetary policies for macroeconomic stabilization and to reduce unemployment.[18]

With the onset of the COVID-19 pandemic, Governors primarily focus on speeches about monetary policy and community development, next to financial stability concerns.[19] Regarding speeches associated with "*Monetary Policy Implementation*" and "*Stabilization Policy,*" Governors address the results of the monetary policy strategy review[20] and provide explanations and discussions on the economic outlook and how the FED reacted during the pandemic recession,[21] respectively. Regarding "*Community Development*" (topic 10), Governors discuss the adverse economic effects of the pandemic on the labor market and the distributional consequences on minorities. How the community reinvestment act (CRA) supports communities and small- and medium-sized enterprises is also discussed.[22]

Does evidence exist in the corpus that is indicative of the changes in the monetary policy strategy between the years 2012 and 2020?[23] Examining the fourth topic, "*Stabilization Policy,*" indicates that a learning process took place at the Board of Governors between strategic reviews. One noticeable change concerns the assessment of whether the federal fund rate's decline alone can ensure fulfilling the dual mandate as the FED's policy rate approaches the ZLB.[24] This observation is addressed several times after interest rates begin to rise at the end of 2015 (for example, Brainard (2015), Powell (2018)). The Governors' explanations rest on developments in the real side of the economy and demographic factors. For example, Fischer (2016, 2017) notes that demographic developments and the increased desire to accumulate savings put downward pressure on long-term interest rates. As a theoretical underpinning, Governors call attention to the *natural real interest rate* to emphasize the importance of considering real economic factors when explaining the reasoning behind the low historical level of interest rates (for example, Fischer (2017), Clarida (2019)).

The Governors also mention growing acceptance of short-term inflation overshooting to stabilize inflation expectations (Brainard, 2018) even before it became incorporated into the new monetary policy strategy as Average Inflation Targeting (AIT) in 2020. AIT is intended to ensure that the FED has room to maneuver in future recessions and to minimize *shortfalls*[25] from the level of full employment.

[13] In the Appendix, we provide example speeches with their gamma values for the topics we focus on for FED and ECB.

[14] In the Appendix, we provide a bar chart which identifies the most important keywords and respective beta values and Appendix B explains the categorization procedure for the topics of the FED Board of Governors.

[15] We provide the prevalence for all topics of both the central banks in the Appendix.

[16] At the end of the Appendix, we provide a list of all *illustrative speeches* that we refer to.

[17] For example, see Greenspan (1997, 2000, 2002, 2004) and Bernanke (2006, 2007).

[18] In the Appendix, we provide additional keywords for the four topics we emphasized for the FED. Employment-related keywords appear primarily in the monetary policy-related topic *Stabilization Policy*.

[19] The Appendix provides the ratio for each topic to the overall number of speeches during the time between March 2020 and March 2021.

[20] for example, Powell (2020a), Clarida (2020), and Clarida (2021).

[21] for example, Brainard (2020d), Powell (2020b), and Powell (2021).

[22] for example, Brainard (2020a), Brainard (2020b), Brainard (2020c), and Brainard (2020e).

[23] In 2012, the Federal Reserve published a strategic review.

[24] Unlike the ECB, the FED has rejected negative interest rates. In an interview with Adam S. Posen, Powell reaffirms this position, see https://www.piie.com/events/economic-update-fed-chair-jerome-h-powell (Last Access: 26 October 2021).

[25] The FOMC removed the word *deviations* to highlight "that a low unemployment rate by itself, in the absence of evidence that price inflation is running or is likely to run persistently above mandate-consistent levels or pressing financial stability concerns, will not, under our new framework, be a sufficient trigger for policy action." (Clarida, 2020).

Fig. 2. Development Mandate-related Topics of FED and ECB Note: This diagram illustrates the prevalence of the mandate-related topics identified with the STM, using $K = 10$ ($K = 13$) for the FED Board of Governors (ECB Executive Board) between 1996 and 2020 (1999 and 2020) annually. We use 10 (13) topics to provide the highest interpretability and clarity. We provide the prevalence for all identified topics in the Appendix.

4.2. Single Mandate: ECB Executive Board

Analogously to Section 4.1, we choose K for the corpus of speeches of the ECB Executive Board from the set of Pareto efficient STMs. Aiming for interpretability, we choose $K = 13$ as the suitable number of topics, though the selection of K does not affect our results (see Section 7). From the 13 topics identified, we categorize four topics that are associated with keywords and content that relate to inflation and unemployment: topic two "*Conventional Monetary Policy,*" topic five "*Unconventional Monetary Policy,*" topic eight "*Monetary Policy in a Changing Environment,*" and topic ten "*Labor Market.*"[26]

[26] The Appendix provides a bar chart that identifies the most important keywords and respective beta values and Appendix B explains the categorization procedure for the topics of the ECB Executive Board.

The lower part of Fig. (2) provides an overview of the development of the mandate-related topics of the speech corpus over time.[27] Looking at the relative proportions, we spot some key characteristics of the corpus. The STM assigns most of the speeches between 1999 and 2011 with the keywords "*monetari,*" "*polici,*" "*stabil,*" "*price,*" and "*euro*" to the topic "*Conventional Monetary Policy.*" Furthermore, most of the speeches after 2011 with keywords like "*monetari,*" "*inflat,*" "*purchase,*" "*rate,*" "*term,*" and "*bank*" are associated with the topic "*Unconventional Monetary Policy.*" The noticeable decline in the relative importance of topic two goes hand in hand with a discernible increase in the absolute number and proportion of speeches assigned to topic five. Specifically, this occurs in 2010/2011, roughly coinciding with the change in presidency from Jean-Claude Trichet (2003–2011) to Mario Draghi (2011–2019).

In the speeches under topic two, central bankers emphasize the importance of central bank independence and sustainable public finances in the euro area member states for the institutions of the Eurosystem and to sustain price stability (for example, Issing (2001), Duisenberg (2003), Papademos (2005)). In contrast, the speeches under topic five, "*Unconventional Monetary Policy,*" focus on the rationale for implementing unconventional monetary policies at the ZLB and persistently low inflation rates. Furthermore, Executive Board members explain the functioning and effects of policies such as quantitative easing or forward guidance.

Another characteristic is the low relevance of labor market-related words in all speeches on topics dealing with monetary policy. Instead, we identify the topic "*Labor Market*" (topic 10). In speeches on this topic, European central bankers do not emphasize monetary policy as an instrument to reduce unemployment. Instead, the central bankers address unemployment and labor productivity from a longer-term perspective. Accordingly, these speeches contain references to "*structural reforms*" or supply-side reforms to increase productivity (for example, Trichet (2005a, 2005b, 2006, 2007)). Following the GFC, on the one hand, we can see a decline importance of the "*Labor Market*" topic in the corpus. On the other hand, central bankers continue to communicate unemployment issues as a structural problem (for example, Draghi (2017)). Fortes and Guenedal (2020), analyzing different means of communication of the ECB, reach a similar conclusion about labor productivity communication.[28]

Analyzing the content of speeches also exposes the intellectual path taken from the strategy review in 2003 to the strategy review in 2021. In line with the communication about monetary policy visible in the speeches delivered by Executive Board members, the European Central Bank (2021a) finally incorporates the instruments considered "unconventional" into its standard repertoire. This is also consistent with scholars' views who point out that the financial crises in recent years mark the transformation of the ECB from an ordoliberal institution modeled on the Deutsche Bundesbank into an American-type central bank that does not hesitate to intervene in the market by conducting large-scale asset purchases (Brunnermeier et al. (2016),Ferrara (2020)). Nevertheless, consistent with the ECB's primary mandate, unemployment is not discussed, confirming findings from the speeches that unemployment is not a macroeconomic objective which is actively pursued by monetary policy.[29]

5. How mandates affect the tone of speeches

So far, we have considered the content of FED and ECB Board members' speeches to identify the main topics being covered and whether they reflect the mandates of each central bank. We next consider how mandates are reflected in the tone of speeches.

5.1. Regression specification

Speeches offer central bankers an opportunity to communicate to the public the mandate they have been given. Central bankers also use speeches to share their assessment of the current macroeconomic situation and outlook. This information can be of high value for market participants since these assessments may contain relevant implications for the future course of monetary policy. From this perspective, one can view central bank speeches as complements to more formal monetary policy tools.

That raises the question of whether a central bank's mandate affects the tone of speeches. For example, we would expect both central banks to change their tone when inflation is rising and is expected to rise in the future. Analogously, we would expect a significant softening of the tone in response to an increase in past or anticipated future unemployment rates. That said, given that the FED has a dual mandate while the ECB has a single mandate, we would expect FED speeches to react more strongly to labor market developments than the ECB. Just as these considerations are reflected in Taylor rules used to explain the setting of short-term interest rates (Taylor (1993),Coibion and Gorodnichenko (2012)), we ask whether inflation and unemployment performance impact the tone of speeches? To test this hypothesis, we estimate the following regression:

[27] Feldkircher et al. (2021) identified similar topics using a data set consisting of speeches by the ECB Executive Board and national central bank presidents of the Eurosystem.

[28] In the Appendix, we provide additional keywords for the four topics we emphasized for the ECB. As clearly visible, practically all employment-related keywords appear in the topic *Labor Market* which does not contain words related to monetary policy.

[29] This is also observable during the COVID-19 pandemic. In the Appendix, we provide the ratio of each topic to the overall number of speeches between March and December 2020. Speeches associated with the fifth topic, "*Unconventional Monetary Policy*", gain significant importance. Executive Board members discuss and explain unconventional and novel monetary policy instruments to combat the pandemic's adverse effects and guarantee price stability while barely mentioning unemployment. Examples are: Schnabel (2020), Lane (2020a, 2020b), Mersch (2020), and Lagarde (2020).

$$\begin{aligned} tone_t = \beta_0 \quad & +\beta_1 * E_t x_{t+3}^{Infl} + \beta_2 * E_t x_{t+3}^{Unemp} + \beta_3 * \bar{\pi}_t \\ & +\beta_4 * \bar{u}_t + \beta_5 * \bar{i}_t + \beta_6 * tone_{t-1} + \sum_{i=7} \beta_i * X_{it} + \epsilon_t \end{aligned} \tag{1}$$

The dependent variable is the average tone of central bank speeches ($tone_t$). Determinants include expectations about inflation ($E_t x_{t+3}^{Infl}$) and unemployment ($E_t x_{t+3}^{Unemp}$) for the current and the next three quarters. For the backward-looking determinant, we use the averages of inflation ($\bar{\pi}_t$) and unemployment ($\bar{u}_t$) from previous months covering the period prior to the release of a forecast at quarter t. The selection of the time horizon for averaging must take into account data availability in real-time. Therefore, we choose six-month averages to capture the current macroeconomic environment that is usually part of speeches by central bankers. Nonetheless, to ensure that this decision does not affect our results, we also consider specifications with nine-month and twelve-month averages. Furthermore, to control for the current stance of monetary policy ($\bar{i}_t$), we utilize the shadow policy rate of Wu and Xia (2016) since this measure incorporates the effect of unconventional monetary policies on financing conditions.[30] We define $\bar{i}_t$ analogously to the other backward-looking variables. Finally, we lag our dependent variable ($tone_{t-1}$) to accommodate persistence in this variable. As additional control variables ($\sum_{i=7} X_{it}$), we use the first lag of the forward-looking independent variables[31] and a dummy variable that equals one if the economy is in a recession. We rely on the recession chronologies of the NBER and CEPR for the FED and ECB, respectively.[32] To account for the ESDC, we include an additional dummy variable set to 1 for the period May 2010 to June 2013 for the ECB specification (Hartmann and Smets, 2018).

We build our analysis partly on Coibion and Gorodnichenko (2011, 2012), who document that it is appropriate to approximate expectations with forecasts when resorting to Taylor rules.[33] For the FED and the ECB, we use the quarterly published forecasts from the Survey of Professional Forecasts (SPF) for each central bank. Using the SPF forecasts offers several advantages: SPF provides forecasts for different time horizons, including short-term and long-term forecasts, and the publication dates between every new publication of the SPF form a consistent quarterly time series regarding the length of each observation. Furthermore, the SPF is available to the general public such that the public is aware of the forecasts when central bankers deliver their speeches.[34] Finally, using SPF forecasts have the advantage that they are constructed in a similar manner for the U.S. and the euro area.

To construct consistent one-year ahead expectations for the FED Board of Governors, we use an average weighting approach similar to Benanni and Neuenkirch (2017) on the current and following calendar year forecasts of the SPF. However, instead of constructing daily expectations, we weight the current and next year forecasts by the number of quarters left until the year-end, including the current quarter. The following equation defines our proxy for the expectations of the Board of Governors:

$$E_t x_{t+3}^{J,FED} = \frac{Q}{4} E_t x_{cy}^{J,FED} + \frac{4-Q}{4} E_t x_{ny}^{J,FED} \quad for\ J \in \{Inflat, Unemp\} \tag{2}$$

where x_{cy}^{J} represents the current calendar year forecasts while x_{ny}^{J} is the forecast for the next calendar year. Q is the number of remaining quarters until the end of the year. We use the same approach for the SPF published by the ECB to proxy the short-term inflation and unemployment expectations of the Executive Board:[35]

$$E_t x_{t+3}^{J,ECB} = \frac{Q}{4} E_t x_{cy}^{J,ECB} + \frac{4-Q}{4} E_t x_{ny}^{J,ECB} \quad for\ J \in \{Inflat, Unemp\} \tag{3}$$

Current macroeconomic developments for the U.S. are captured by the inflation rate in the Personal Consumption Expenditure Price Index (PCE) and the average change of the seasonally adjusted monthly unemployment rate from the U.S. Bureau of Labor Statistics.[36] For the euro area, we use the inflation rate of the Harmonized Consumer Price Index and the average change of the seasonally adjusted monthly unemployment rate from the Labor Force Survey.[37] Depending on the specification, these averages consist of six, nine, and twelve months.[38]

[30] Since Wu and Xia (2016) provide their shadow interest rate for the Eurosystem from 2005, we fill the missing years with the interest rate for the main refinancing operations of the ECB.

[31] We do not include lags of the backward-looking variables to avoid overlapping, since we consider at least six months' averages while our data is quarterly.

[32] NBER: https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions (last access: 9 November 2021). CEPR: https://eabcn.org/dc/chronology-euro-area-business-cycles (last access: 9 November 2021).

[33] As long as the forecast is independent of the monetary policy decision, such estimated models are not considered to be misspecified.

[34] The obvious disadvantage of the SPF is that they are not forecasts of the FED. Instead, we could use the FED's Greenbook forecasts. Unfortunately, these are only available with a five year lag. When Greenbook forecasts are used our conclusions are unaffected (not shown but see the Appendix).

[35] We also use, in the Appendix, forecast encompassing tests (Cook, 2014) which favor the usage of SPF instead of the ECB/Eurosystem staff projections. Nonetheless, the results remain robust when using the ECB/Eurosystem projections.

[36] We downloaded the data from FRED Economic Data of the St. Louis FED: *PCEPI* (BEA Account Code: DPCERG) and *UNRATE* (Source Code: LNS14000000) (Last Access: 29 October 2021).

[37] We downloaded the data from the ECB Statistical Data Warehouse: *HICP* and *Unemployment rate* (Last Access: 29 October 2021).

[38] In the Appendix, we provide a graphical comparison of the development in the expected and actual inflation and unemployment rate for the U.S. and the euro area.

5.2. Tone of speeches

To quantify the tone of text data, we use sentiment analysis. We choose an appropriate lexicon and apply a search-and-count algorithm to our two corpora independently. Loughran and McDonald (2011) is a well-known study and lexicon about sentiment analysis where the authors also document that one needs a different lexicon for economics texts than for the analysis of everyday language. Shapiro and Wilson (2021) and Paloviita et al. (2020) use the lexicon of Loughran and McDonald (2011) to analyze the sentiment of FED transcripts and ECB press conference statements, respectively. Scholars like Picault and Renault (2017) argue that central bank communication needs a more field-specific lexicon due to differences in communication styles between central banks and corporations. Furthermore, for our analysis, the same lexicon should encompass language used by both central banks and should not be tailored to one or the other central bank.[39]

We use the Apel et al. (2019) lexicon, which is an updated version of the dictionary originally developed by Apel and Blix Grimaldi (2014) and is designed based on the transcripts and minutes of the FOMC. The simple bi-gram approach focusing on the mandate-related topics "*Inflation,*" "*Economic Activity,*" and "*Employment*" makes this dictionary attractive for comparative analyses based on English-written documents of central banks due to the wide usage of the selected words. Furthermore, the lexicon by Apel et al. (2019) permits a distinction between hawkish and dovish word combinations. As a difference to Apel et al. (2019), we use the lexicon and our search-and-count algorithm on stemmed speeches. Furthermore, we only consider all direct word combinations of the terms and their respective modifiers, though without considering stop words.[40] To measure the sentiment of each speech i at t, we define the following indicator:

$$NetSentiment_{t_i} = 100 * \frac{Hawk_{t_i} - Dove_{t_i}}{\frac{1}{2} * N_{t_i}} \tag{4}$$

Since the terms our search-and-count algorithm detects are bi-grams, we divide the net tone of each speech by the absolute number of words, N_{t_i}, and divide by $\frac{1}{2}$.[41] Doing this, we adjust for the lengths of speeches[42] and consider using bi-grams.[43] The last step simplifies the interpretation without affecting the estimation.

In the next step, we follow Moschella and Pinto (2019) and cluster the topics into three categories: primary mission, secondary mission, and ancillary mission of the respective central banks. Using the classification scheme of Moschella and Pinto (2019) leads to an exclusive focus on topics dealing only with monetary policy. Otherwise, we risk biasing the quantification of the tone of speeches since dictionaries relating to monetary policy may not fit with speeches dealing with education or financial stability (Correa et al., 2021). Therefore, we combine topics four and eight of the FED Board of Governors corpus into an aggregate primary mandate topic. Analogously, we combine topics two, five, and eight of the ECB Executive Board corpus. Now we run our search-and-count algorithm with Apel et al. (2019) dictionary on the primary mandate topics of the respective central banks. We calculate the average tone for each period t:

$$tone_t = \frac{1}{N}\sum_{i=1}^{N} NetSentiment_{t_i} \tag{5}$$

Fig. (3) plots the development of $tone_t$ for the speeches of the FED Board of Governors and ECB Executive Board and add recessions as shaded areas based on the recession dates of the NBER and CEPR.

We identify some interesting differences between the two central banks. The tone of speeches by the Board of Governor members becomes steadily more dovish from mid-1996 until 2006. By the beginning of the 2000s, the number of dovish surpasses the number of hawkish terms. Interestingly, although the tone has become gradually more hawkish since the GFC, it took about seven years before the average number of hawkish terms surpassed dovish terms. In contrast, the tone of speeches by the ECB is relatively more volatile than the tone emanating from the FED. This may reflect differences in the distribution of speeches given across members of the FED's Board of Governors versus the ECB's Executive Board (see tables in the Appendix). Furthermore, the tone of Executive Board members speeches appear to be more responsive around recessions. Looking at the individual data points, we can detect that the tone of the ECB's Executive Board becomes abruptly more dovish during every recession in our sample.

[39] Benanni and Neuenkirch (2017) provide a field-specific lexicon based on speeches of Executive Board members of the ECB and the national central bank presidents of the Eurosystem. Analogously, Neuhierl and Weber (2019) offer a field-specific lexicon based on speeches by Board of Governors members of the FED during the 2000s. For our analysis, these dictionaries are unsuitable.

[40] Apel et al. (2019) provide their dictionary in the Appendix of their paper. Considering direct word combinations ensures that we count unambiguous n-grams. However, we effectively have a flexible word window since we do not consider stop words. We include the terms "core inflation", "inflation rate", and "inflation expectations" with the same list of modifiers as "inflation".

[41] The three uni-gram terms in Apel et al. (2019) can be interpreted as bi-grams together with their modifiers. This interpretation does not affect the estimation, though it simplifies the interpretation of the results.

[42] N_t does not consider stop words that we take from the established dictionaries *Onix, SMART,* and *Snowball.*

[43] Another indicator to derive the sentiment of text is $\frac{Hawk_{t_i} - Dove_{t_i}}{Hawk_{t_i} + Dove_{t_i}}$ (Apel and Blix Grimaldi, 2014). However, this indicator does not consider the length of speeches which varies considerably in contrast to, for example, introductory statements during press conferences.

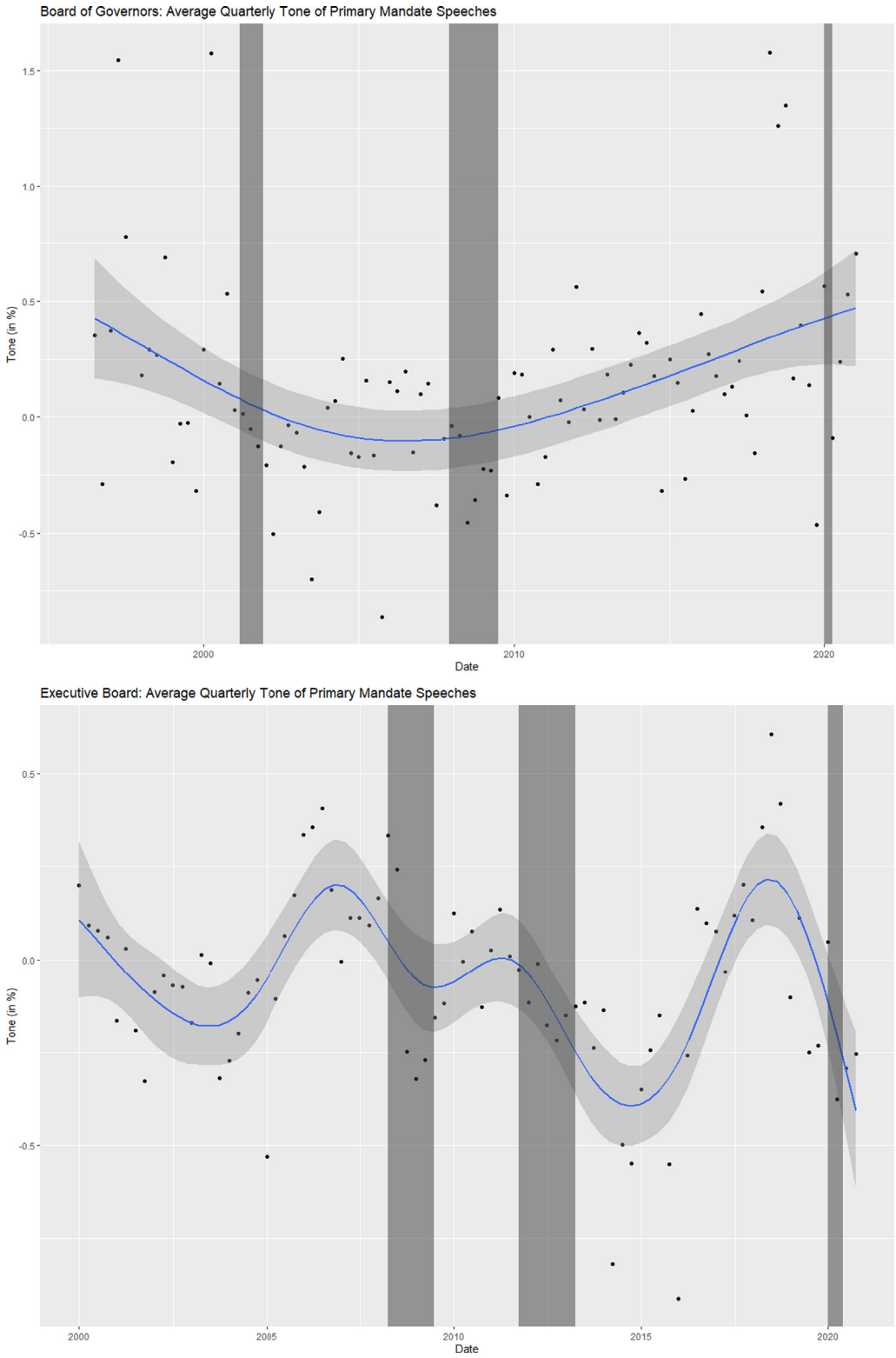

Fig. 3. Average Tone of Primary Mandate Speeches Note: The figures show the average quarterly development of our dependent variable $tone_t$ between 1997–2020 (FED) and 2000–2020 (ECB) using regression splines. We describe the calculation of $tone_t$ in Section 5. We constrain the corpus to speeches that directly relate to the primary mandate of each central bank. We denote recessions with shaded areas using the dates of the recessions of th.e NBER and CEPR.

6. Results

We estimate Eq. (1) using OLS for the entire sample and after splitting the sample at the decadal change from the 2000s to the 2010s. The split is motivated by the thematic shifts in the corpora of the two central banks identified in the fourth section. Table (1) shows the regression results for the FED Board of Governors, and Table (2) shows the results for the ECB Executive Board.

For brevity, we limit the presentation to the central results of our analysis. For the full sample, visible in columns (1) - (3) of Table (1), we estimate a statistically significant effect of unemployment expectations at the 10%-level on the tone of speeches. Consistent with the mandate of the FED, higher unemployment expectations lead to a more dovish tone. The number of hawkish terms to dovish terms decreases significantly after controlling for the length of speeches. In contrast, we do not find a significant effect of backward or forward-looking inflation. Splitting the sample to pre-2009 (columns (4) - (6)) and post-2009 (columns (7) - (9)) reveals that the post-2009 period drives the full sample results. We estimate that, in the post-GFC sample, an increase in unemployment expectations by one percentage point leads, on average, to a net decline in hawkish terms given the length of speech by approximately 0.17 percentage points.[44] This result is robust across the specifications and provides evidence for the increased importance of unemployment expectations after hitting the ZLB. Also noteworthy is the significant positive effect of the policy rate on tone in pre-2009. The parameter sign is consistent with the intuition that a more hawkish tone accompanies policy rate hikes while a more dovish tone accompanies policy rate reductions. A likely explanation is that speeches are also used to explain changes in the stance of monetary policy.

Table (2) presents the results for the ECB Executive Board. Neither expected nor past unemployment development have a statistically significant impact on tone. Instead, in the full sample specifications (columns (1) - (3)), we estimate a statistically and economically significant effect of inflation expectations on the tone of speeches. This result is consistent with our hypothesis that inflation development affects Executive Board members speeches' tone which is consistent with the ECB's price stability mandate. The positive parameter sign is consistent with our hypothesis that higher inflation risks lead to a more hawkish tone in the speeches. Moreover, the result is consistent with the theoretical perspective that private-sector inflation expectations determine the actual inflation rate rather than past developments since past inflation and unemployment do not impact the tone of speeches. If the private sector expects lower inflation, it may lead to lower increases in prices and wages, resulting in downward risks for the inflation target. As a response, the ECB's Executive Board changes the tone of its speeches to stabilize inflation expectations. After splitting the full sample into pre-2009 (columns (4) - (6)) and post-2009 (columns (7) - (9)) samples, similar to the Board of Governors, it is likely that the post-2009 period drives the full sample results. We only estimate a statistically significant effect of inflation expectations on tone for the post-2009 sample regardless of the specification.

For the pre-2009 period, as seen in columns (5) - (6), we estimate a significant effect of inflation and unemployment expectations on the tone of speeches. However, expectations no longer affect the tone of speeches when we use shorter horizons to construct $\bar{\pi}_t$ and $\bar{u}_t$, implying that central bankers focus only on more recent developments. One should recall that, during the first decade of the ECB, the central bank was undoubtedly preoccupied with a need to explain its role, build its credibility, and inform the public about the implications of a single monetary policy. Moreover, inflation developments rarely threatened the ECB's price stability definition (that is, inflation below but close to 2%) before the crisis-prone era that began after 2009. Finally, it may be that the tone of pre-2009 speeches sought to reassure the public that, despite the Maastricht Treaty's emphasis on price stability, Executive Board members wanted to convey the impression that they are not inflation 'nutters' and comment on every change in short-term inflation expectations. Despite using a different specification with a lexicon not tailored to the Eurosystem, our results are consistent with Benanni and Neuenkirch (2017) concerning the increased importance of inflation expectations to the ECB since the GFC.

Next, we examine how *long-term* inflation expectations affect the tone of the speeches. Central bankers may focus on long-term inflation forecasts since price stability is a macroeconomic aim that central banks want to achieve in the medium to the long-run. Therefore, we re-write Eq. (1) as follows:

$$\begin{aligned} tone_t = \beta_0 + \beta_1 * E_t x_{t+3}^{Infl} + \beta_2 * E_t x_{LT}^{Infl} + \beta_3 * E_t x_{t+3}^{Unemp} + \beta_4 * \bar{\pi}_t \\ + \beta_5 * \bar{u}_t + \beta_6 * \bar{i}_t + \beta_7 * tone_{t-1} + \sum_{i=8} \beta_i * X_{it} + \epsilon_t \end{aligned} \tag{6}$$

Long-term inflation expectations ($E_t x_{LT}^{Infl}$) are proxied by the ten-year forecasts for inflation from the SPF for the FED and by the five-year forecasts from the SPF for the ECB.[45]

Table (3) shows the results for the Board of Governors. The full sample results stay qualitatively similar to ones in Table (1). For example, our earlier finding that inflation expectations do not affect the tone of speeches remains unchanged.

[44] Ehrmann et al. (2021), exploiting the exogeneity of the voting rotation procedure at the FED, show that the decision to hold a speech and the tone of speeches of regional Federal Reserve Bank presidents also depends on unemployment. Furthermore, after extending their sample until 2018, regional unemployment affects the tone of speeches regardless of the voting right. One can consider these results complementary to our findings due to our focus on the Board of Governors.

[45] We use ten-year inflation forecasts since the Federal Reserve Bank of Philadelphia published five-year forecasts for inflation only since the third quarter of 2005. Nonetheless, in the robustness check, we find that using five-year inflation forecasts for the second estimation period does not have significant qualitative effects on the results.

Table 1
FED Board of Governors - Tone.

	(1) $tone_t$ Full	(2) $tone_t$ Full	(3) $tone_t$ Full	(4) $tone_t$ Pre	(5) $tone_t$ Pre	(6) $tone_t$ Pre	(7) $tone_t$ Post	(8) $tone_t$ Post	(9) $tone_t$ Post
$E_t x_{t+3}^{Infl}$	0.03	0.02	0.04	0.10	0.08	0.11	0.16	0.16	0.17
	(0.11)	(0.11)	(0.11)	(0.21)	(0.20)	(0.21)	(0.22)	(0.21)	(0.20)
$E_t x_{t+3}^{Unemp}$	−0.11*	−0.09*	−0.10*	0.16	0.16	0.18	−0.17***	−0.16***	−0.16***
	(0.06)	(0.06)	(0.05)	(0.44)	(0.38)	(0.38)	(0.06)	(0.06)	(0.05)
$\bar{\pi}_t^{6m}$	−0.02			−0.03			−0.05		
	(0.07)			(0.07)			(0.14)		
$\bar{u}_t^{6m}$	0.00			−0.05			0.00		
	(0.00)			(0.05)			(0.00)		
$\bar{i}_t^{6m}$	0.00			0.11**			0.02		
	(0.02)			(0.05)			(0.05)		
$\bar{\pi}_t^{9m}$		0.04			0.06			−0.05	
		(0.07)			(0.06)			(0.10)	
$\bar{u}_t^{9m}$		0.01			−0.07			0.01	
		(0.01)			(0.05)			(0.01)	
$\bar{i}_t^{9m}$		0.01			0.13***			0.01	
		(0.02)			(0.04)			(0.05)	
$\bar{\pi}_t^{12m}$			−0.03			−0.03			−0.04
			(0.06)			(0.08)			(0.08)
$\bar{u}_t^{12m}$			0.01			−0.10			0.01
			(0.01)			(0.06)			(0.01)
$\bar{i}_t^{12m}$			−0.00			0.09**			0.00
			(0.02)			(0.04)			(0.05)
Constant	0.31	0.38	0.34	−0.53	−0.83	−0.45	−0.22	−0.20	−0.16
	(0.33)	(0.31)	(0.29)	(1.15)	(1.16)	(1.22)	(0.38)	(0.31)	(0.30)
Obs	96	96	96	51	51	51	45	45	45
R^2	0.23	0.24	0.23	0.28	0.34	0.26	0.37	0.38	0.38
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Post-GFC	-	-	-	NO	NO	NO	YES	YES	YES
Full Sample	YES	YES	YES	NO	NO	NO	NO	NO	NO

Note: We regress our variables on our sentiment indicator $tone_t$ from Eq. (5). $E_t x_{t+3}^{Infl}$ and $E_t x_{t+3}^{Unemp}$ are the weighted averages of the current and next year forecast for inflation and unemployment from the SPF at quarter t, respectively. $\bar{\pi}_t^{Xm}$, $\bar{u}_t^{Xm}$, and $\bar{i}_t^{Xm}$ denote the average of inflation, unemployment, and the Wu and Xia (2016) shadow interest rate in the X months prior to t, respectively. All specifications include a lag of the dependent variable. Additional control variables are the lags of $E_t x_{t+3}^{Infl}$, $E_t x_{t+3}^{Unemp}$, and a dummy variable that equals one if the economy is in a recession based on NBER. *Full* covers the period June 1996 until March 2021, *Pre* the period June 1996 until December 2009, and *Post* the period January 2010 until March 2021. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

However, when the pre-2009 period is considered, we estimate a significant effect of long-term inflation expectations on tone (columns (4) and (6)). As seen in columns (7) - (9), that is for the post-2009 period, the results remain qualitatively similar to the ones shown in Table (1). The insignificant effect of long-term inflation expectations during this period may be that the focus of the FED was on the slow recovery following the GFC while inflation remained low and often below target (see Fig. (1)).

Table (4) provides the results for the ECB Executive Board. Including long-term inflation expectations has significant qualitative and quantitative effects on the results. We estimate a statistically and economically significant effect of long-term inflation expectations and short-term inflation expectations with parameter signs consistent with our hypothesis. When splitting the sample between pre-2009 and post-2009 periods, significant effects are found only for long-term inflation expectations in the post-GFC sample. We do not estimate any significant effect on tone for the pre-2009 sample. Our estimation provides evidence that European central bankers react strongly to an increase in inflation expectations. This relationship becomes apparent after the GFC when the ZLB is reached and the Executive Board introduces unconventional monetary policy instruments.

Finally, we estimate our specifications by excluding the periods of the GFC (1 September 2008–31 December 2009)[46] and the COVID-19 pandemic (1 March 2021 onwards)[47]. Excluding crisis periods has qualitative effects on speech sentiment at both central banks (results not shown). For the FED, long-term inflation expectations become significant, while lagged policy rate changes become insignificant. The results for the post-2009 period remain qualitatively similar as before.

For the ECB, removing the crisis periods does not have significant qualitative effects on the results. Nonetheless, the significant negative impact of unemployment expectations on the tone of speeches vanishes (results not shown). The insignificant effect of backward- or forward-looking unemployment rates is consistent with the single mandate of the Eurosystem and with our earlier content analysis: the Executive Board communicates unemployment mainly as a structural problem.[48]

[45] We use ten-year inflation forecasts since the Federal Reserve Bank of Philadelphia published five-year forecasts for inflation only since the third quarter of 2005. Nonetheless, in the robustness check, we find that using five-year inflation forecasts for the second estimation period does not have significant qualitative effects on the results.

Table 2
ECB Executive Board - Tone.

	(1) $tone_t$ Full	(2) $tone_t$ Full	(3) $tone_t$ Full	(4) $tone_t$ Pre	(5) $tone_t$ Pre	(6) $tone_t$ Pre	(7) $tone_t$ Post	(8) $tone_t$ Post	(9) $tone_t$ Post
$E_t x_{t+3}^{Infl}$	0.29***	0.27***	0.26***	0.09	0.13	0.14*	0.53**	0.50**	0.49**
	(0.11)	(0.10)	(0.09)	(0.08)	(0.08)	(0.08)	(0.21)	(0.21)	(0.22)
$E_t x_{t+3}^{Unemp}$	−0.06	−0.08	−0.09	−0.12	−0.25*	−0.21	0.04	0.04	0.04
	(0.11)	(0.10)	(0.09)	(0.14)	(0.14)	(0.13)	(0.14)	(0.14)	(0.15)
$\bar{\pi}_t^{6m}$	−0.09			0.09			−0.20**		
	(0.07)			(0.11)			(0.10)		
$\bar{u}_t^{6m}$	0.00			−0.11**			−0.01		
	(0.03)			(0.06)			(0.03)		
$\bar{i}_t^{6m}$	−0.01			−0.05			−0.02		
	(0.01)			(0.04)			(0.02)		
$\bar{\pi}_t^{9m}$		−0.05			0.02			−0.11	
		(0.06)			(0.10)			(0.11)	
$\bar{u}_t^{9m}$		0.02			−0.03			0.00	
		(0.03)			(0.06)			(0.05)	
$\bar{i}_t^{9m}$		−0.01			−0.04			−0.01	
		(0.01)			(0.04)			(0.02)	
$\bar{\pi}_t^{12m}$			−0.01			0.02			−0.05
			(0.06)			(0.08)			(0.12)
$\bar{u}_t^{12m}$			0.02			−0.05			0.01
			(0.04)			(0.04)			(0.05)
$\bar{i}_t^{12m}$			−0.01			−0.05			−0.00
			(0.01)			(0.04)			(0.02)
Constant	0.22	0.28	0.29	1.10***	0.99**	0.94**	−0.20	-0.00	0.15
	(0.25)	(0.25)	(0.25)	(0.36)	(0.39)	(0.40)	(0.38)	(0.48)	(0.54)
Obs	83	83	83	39	39	39	44	44	44
R^2	0.53	0.53	0.53	0.61	0.59	0.59	0.55	0.54	0.54
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Post-GFC	-	-	-	NO	NO	NO	YES	YES	YES
Full Sample	YES	YES	YES	NO	NO	NO	NO	NO	NO

Note: We regress our variables on our sentiment indicator $tone_t$ from Eq. (5). $E_t x_{t+3}^{Infl}$ and $E_t x_{t+3}^{Unemp}$ are the weighted averages of the current and next year forecast for inflation and unemployment from the SPF at quarter t, respectively. $\bar{\pi}_t^{Xm}$, $\bar{u}_t^{Xm}$, and $\bar{i}_t^{Xm}$ denote the average of inflation, unemployment, and the Wu and Xia (2016) shadow interest rate in the X months prior to t, respectively. Before 2005, we use the interest rate for the main refinancing operations. All specifications include a lag of the dependent variable. Additional control variables are the lags of $E_t x_{t+3}^{Infl}$, $E_t x_{t+3}^{Unemp}$, a dummy variable that equals one if the economy is in a recession based on CEPR, and a dummy that considers the ESDC (May 2010 - June 2013). *Full* covers the period January 1999 until December 2020, *Pre* the period January 1999 until December 2009, and *Post* the period January 2010 until December 2020. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In contrast, FED Governors increasingly communicate about labor market conditions since the GFC with unemployment expectations having a significant impact on the tone of speeches.

7. Robustness Checks and Additional Results

We perform several robustness checks. All results are relegated to a separate Appendix. Our results remain robust when using specifications with nine or twelve-month averages for the variables $\bar{\pi}_t, \bar{u}_t$, and $\bar{i}_t$ (see Eq. (1)).

We tried different values for K, that is, the number of topics. The results remain robust when using $K \in \{8, 9\}$ and $K \in \{12\}$ for the FED and ECB, respectively.

We also replaced the short-term shadow rate of Wu and Xia (2016) with the shadow rate estimates of Krippner (2013) and for different values of K. Our conclusions remain unchanged.

Next, we replaced the short- and long-term inflation forecasts based on CPI data with PCE forecasts. The results remain robust when using the five-year inflation forecast or using PCE forecasts regardless of which shadow rate we use and for all values of K.

To ensure that potential structural breaks do not bias our results, we implement the computational and graphical multiple breakpoint identification approach of Zeileis et al. (2003). For the FED Board of Governors, we identify a structural breakpoint at the year-end of 2016.[49] We estimate our model specifications for 1996–2016, with and without the GFC period, and post-2009. The estimation results remain robust and analogous to our estimation results for the post-2009 sample shown in

[46] We define the period for the GFC from September 2008, the bankruptcy of Lehman Brothers, until the end of 2009.

[47] The World Health Organization (2020) declared COVID-19 on 11 March 2020 as a pandemic.

[48] A potential concern could be that the ECB Executive Board does not communicate directly about unemployment but indirectly by referring to the business cycle and economic activity, which would be consistent with the secondary mandate of the Eurosystem. To test this hypothesis, we redefine our dependent variable $tone_t$ using only the "*Economic Activity*" sub dictionary of Apel et al. (2019). Our conclusions remain unchanged.

Table 3
FED Board of Governors - Considering Long Term Inflation Forecasts.

	(1) $tone_t$ Full	(2) $tone_t$ Full	(3) $tone_t$ Full	(4) $tone_t$ Pre	(5) $tone_t$ Pre	(6) $tone_t$ Pre	(7) $tone_t$ Post	(8) $tone_t$ Post	(9) $tone_t$ Post
$E_t x_{t+3}^{Infl}$	0.03	0.03	0.03	0.11	0.09	0.11	0.18	0.15	0.16
	(0.11)	(0.11)	(0.12)	(0.19)	(0.19)	(0.19)	(0.18)	(0.17)	(0.17)
$E_t x_{10Y}^{Infl}$	−0.01	−0.06	0.07	1.00*	0.89	0.99*	−0.15	0.12	0.10
	(0.39)	(0.40)	(0.39)	(0.52)	(0.52)	(0.51)	(1.08)	(1.20)	(1.17)
$E_t x_{t+3}^{Unemp}$	−0.11*	−0.09*	−0.10*	0.35	0.29	0.33	−0.17***	−0.16***	−0.16***
	(0.06)	(0.06)	(0.06)	(0.39)	(0.36)	(0.36)	(0.05)	(0.05)	(0.05)
$\bar{\pi}_t^{6m}$	−0.02			−0.02			−0.04		
	(0.07)			(0.07)			(0.15)		
$\bar{u}_t^{6m}$	0.00			−0.06			0.00		
	(0.01)			(0.05)			(0.01)		
$\bar{i}_t^{6m}$	0.00			0.08**			0.02		
	(0.03)			(0.04)			(0.05)		
$\bar{\pi}_t^{9m}$		0.04			0.06			−0.05	
		(0.07)			(0.06)			(0.11)	
$\bar{u}_t^{9m}$		0.00			−0.05			0.01	
		(0.01)			(0.05)			(0.01)	
$\bar{i}_t^{9m}$		0.01			0.11***			0.01	
		(0.03)			(0.04)			(0.05)	
$\bar{\pi}_t^{12m}$			−0.03			−0.03			−0.04
			(0.06)			(0.07)			(0.09)
$\bar{u}_t^{12m}$			0.01			−0.07			0.01
			(0.01)			(0.06)			(0.01)
$\bar{i}_t^{12m}$			−0.00			0.06*			0.00
			(0.03)			(0.03)			(0.05)
Constant	0.33	0.47	0.21	−2.16	−2.24	−1.99	0.06	−0.41	−0.34
	(0.84)	(0.85)	(0.83)	(1.92)	(1.96)	(1.92)	(1.91)	(2.07)	(2.02)
Obs	96	96	96	51	51	51	45	45	45
R^2	0.23	0.24	0.23	0.35	0.40	0.33	0.38	0.38	0.38
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Post-GFC	-	-	-	NO	NO	NO	YES	YES	YES
Full Sample	NO	NO	NO	NO	NO	NO	YES	YES	YES

Note: We regress our variables on our sentiment indicator $tone_t$ from Eq. (5). $E_t x_{t+3}^{Infl}$ and $E_t x_{t+3}^{Unemp}$ are the weighted averages of the current and next year forecast for inflation and unemployment from the SPF at quarter t, respectively. $\bar{\pi}_t^{Xm}$, $\bar{u}_t^{Xm}$, and $\bar{i}_t^{Xm}$ denote the average of inflation, unemployment, and the Wu and Xia (2016) shadow interest rate in the X months prior to t, respectively. Furthermore, we include the ten year inflation forecast $E_t x_{10Y}^{Infl}$ from the SPF. All specifications include a lag of the dependent variable. Additional control variables are the lags of $E_t x_{t+3}^{Infl}$, $E_t x_{t+3}^{Unemp}$, and a dummy variable that equals one if the economy is in a recession based on NBER. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table (3). In the case of the ECB Executive Board, we cannot identify any structural breaks. Despite the possibility of structural breaks, our conclusions remain unchanged.

As previously discussed, we also used the Greenbook forecasts for the FED Board of Governors, while for the ECB Executive Board, we used the Eurosystem staff projections instead of SPF forecasts.[50] Our results remain unchanged.

Finally, we focus only on speeches of the chair (president) of the FED (ECB) and disaggregate the data using the daily estimation approach of Benanni and Neuenkirch (2017). Our conclusions remain robust.[51]

8. Conclusions

This study examines the influence of central bank mandates on the content and tone of speeches made by senior officials at the FED and the ECB. We contribute to the existing literature by creating a study design that allows for a proper comparison between the dual-mandate of the FED and the single-mandate of the ECB. Although speeches about monetary policy objectives reveal similarities at both central banks during the Great Moderation differences emerge following the GFC. Both central banks, however, discuss the usage and novelty of unconventional monetary policy instruments. Additionally, the FED Governors explain how monetary policy can influence unemployment and assists in restoring full employment. In contrast, ECB Executive Board members focus solely on price stability and, if mentioned at all, consider unemployment primarily as a structural problem.

Regarding the tone of speeches, these parallel the results of the content analysis. Before the GFC, we could not detect a significant difference between both central banks. While long-term inflation expectations influence the tone of FED Governors speeches, we cannot estimate any significant effect of inflation on the tone of ECB Executive Board members' speeches.

[50] We use those central bank forecasts whose release is closest to the beginning of a new quarter in estimating Eq. (6).

[51] One difference between speeches given by the chair and the entire Board of Governors is the significant effect of backward-looking unemployment data on tone.

Table 4
ECB Executive Board - Considering Long Term Inflation Forecasts.

	(1) $tone_t$ Full	(2) $tone_t$ Full	(3) $tone_t$ Full	(4) $tone_t$ Pre	(5) $tone_t$ Pre	(6) $tone_t$ Pre	(7) $tone_t$ Post	(8) $tone_t$ Post	(9) $tone_t$ Post
$E_t x_{t+3}^{Infl}$	0.23**	0.22**	0.21**	0.11	0.16*	0.16*	0.34*	0.28	0.28
	(0.10)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)	(0.18)	(0.18)	(0.18)
$E_t x_{5Y}^{Infl}$	1.19***	1.19***	1.20***	−0.28	−0.62	−0.38	2.15***	2.18***	2.12***
	(0.36)	(0.37)	(0.38)	(0.68)	(0.76)	(0.73)	(0.67)	(0.66)	(0.66)
$E_t x_{t+3}^{Unemp}$	−0.08	−0.10	−0.10	−0.14	−0.30*	−0.25*	0.02	−0.01	−0.01
	(0.08)	(0.08)	(0.08)	(0.15)	(0.15)	(0.13)	(0.11)	(0.11)	(0.11)
$\bar{\pi}_t^{6m}$	−0.08			0.09			−0.21*		
	(0.07)			(0.12)			(0.11)		
$\bar{u}_t^{6m}$	−0.00			−0.10			0.02		
	(0.03)			(0.07)			(0.05)		
$\bar{i}_t^{6m}$	−0.02**			−0.07			−0.05***		
	(0.01)			(0.05)			(0.02)		
$\bar{\pi}_t^{9m}$		−0.05			0.05			−0.13	
		(0.06)			(0.10)			(0.09)	
$\bar{u}_t^{9m}$		0.01			0.03			0.06	
		(0.03)			(0.08)			(0.06)	
$\bar{i}_t^{9m}$		−0.02**			−0.07			−0.04*	
		(0.01)			(0.05)			(0.02)	
$\bar{\pi}_t^{12m}$			−0.02			0.05			−0.07
			(0.06)			(0.08)			(0.10)
$\bar{u}_t^{12m}$			0.01			−0.01			0.06
			(0.03)			(0.06)			(0.05)
$\bar{i}_t^{12m}$			−0.02**			−0.06			−0.04
			(0.01)			(0.05)			(0.02)
Constant	−1.72***	−1.68***	−1.69**	1.91	2.76	2.04	−3.60***	−3.41***	−3.24**
	(0.60)	(0.61)	(0.62)	(1.74)	(2.12)	(2.00)	(1.08)	(1.18)	(1.22)
Obs	80	80	80	36	36	36	44	44	44
R^2	0.59	0.58	0.58	0.61	0.60	0.59	0.67	0.66	0.65
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Post-GFC	NO	NO	NO	YES	YES	YES	-	-	-
Full Sample	NO	NO	NO	NO	NO	NO	YES	YES	YES

Note: We regress our variables on our sentiment indicator $tone_t$ from Eq. (5). $E_t x_{t+3}^{Infl}$ and $E_t x_{t+3}^{Unemp}$ are the weighted averages of the current and next year forecast for inflation and unemployment from the SPF at quarter t, respectively. $\bar{\pi}_t^{Xm}$, $\bar{u}_t^{Xm}$, and $\bar{i}_t^{Xm}$ denote the average of inflation, unemployment, and the Wu and Xia (2016) shadow interest rate in the X months prior to t, respectively. Before 2005, we use the interest rate for the main refinancing operations. Furthermore, we include the five year inflation forecast $E_t x_{5Y}^{Infl}$ from the SPF. All specifications include a lag of the dependent variable. Additional control variables are the lags of $E_t x_{t+3}^{Infl}$, $E_t x_{t+3}^{Unemp}$, and a dummy variable that equals one if the economy is in a recession based on CEPR, and a dummy that considers the ESDC (May 2010 - June 2013). Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Following the GFC, we estimate significant effects of inflation and unemployment expectations on the tone of speeches, though with substantial qualitative differences between the FED and the ECB. Unemployment expectations influence the tone of speeches by FED Governors, while (long-term) inflation expectations affect the tone of ECB Executive Board member speeches. ECB Executive Board members' speeches are delivered with a tone consistent with their mandate despite the increase in unemployment in the euro area during the last decade. In contrast, a similar development regarding unemployment in the U.S. significantly shifted the content and tone of speeches by Board of Governor members.

Our analysis demonstrates the importance of mandates in driving the content and tone of speeches. Speeches also reflect the economic circumstances when they are delivered. Focusing on mandate-related speeches helps to clarify how the opinions of central bankers change over time.

Therefore, once the COVID-19 pandemic is over, an update of our analysis, we leave for future research, should analyze whether the pandemic results in a pivot in the tone of central bank speeches much as the GFC did. Furthermore, how macro-financial factors and broader societal concerns, such as climate change, influences the content and tone of speeches and whether these are consistent with the central bank's mandate is another avenue of future research. While we focused on speeches related to central banks' primary objectives, one could repeat our analysis by examining tone vis-a-vis secondary and tertiary objectives or analyze the role of mandates on modern means of communication like podcasts and blog articles. All of the foregoing extensions are left for future research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank Michael Ehrmann, Paul Hubert, the editor Kees G. Koedijk, two anonymous referees, and participants at the Corvinus University conference and the European Economics and Finance Society (EEFS) 2022 conference for valuable comments on an earlier draft. We also thank Niklas Humann for his outstanding research assistance. Part of the research for the paper was conducted, while the second author was a visiting scholar at the Balsillie School of International Affairs. He is grateful for the hospitality.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jimonfin.2022.102752.

References

Apel, M., Blix Grimaldi, M., 2014. How Informative Are Central Bank Minutes? Rev. Econ. 65, 53–76.
Apel, M., Blix Grimaldi, M., Hull, I., 2019. How Much Information Do Monetary Policy Committees Disclose? Evidence from the FOMC's Minutes and Transcripts. Sveriges Riksbank Working Paper Series 381.
Bai, J., Perron, P., 2003. Computation and Analysis of Multiple Structural Change Models. J. Appl. Econ. 18, 1–22.
Benanni, H., Neuenkirch, M., 2017. The (Home) Bias of European Central Bankers: New Evidence Based on Speeches. Appl. Econ. 49, 1114–1131.
Bernanke, B., 2004. The Great Moderation. Remarks by Governor Ben S. Bernanke. At the meetings of the Eastern Economic Association, Washington, DC February 20, 2004.
Bernanke, B., 2022. 21st Century Monetary Policy: The Federal Reserve from the Great Inflation to COVID-19. W.W. Norton & Co.
Bholat, D., Hansen, S., Santos, P., Schonhardt-Bailey, C., 2015. Text Mining for Central Banks. Centre for Central Banking Studies Handbook No. 33.
Bischof, J.M., Airoldi, E.M., 2012. Summarizing Topical Content with Word Frequency and Exclusivity. ICML'12: Proceedings of the 29th International Coference on Machine Learning, 9–16.
Blei, D.M., Ng, A.Y., Jordan, M.I., 2003. Latent Dirichlet Allocation. Journal of Machine Learning Research 3, 993–1022.
Blinder, A.S., Ehrmann, M., De Haan, J., Jansen, D.J., 2022. Central Bank Communication with the General Public: Promise or False Hope? CEPR Discussion Paper Series: DP17441.
Blinder, A.S., Ehrmann, M., Fratzscher, M., De Haan, J., Jansen, D.J., 2008. Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence. Journal of Economic Literature 46, 910–945.
Bohl, M., Siklos, P., 2007. Do Actions Speak Louder than Words? Evaluating Monetary Policy at the Bundesbank. J. Macroecon. 29, 368–386.
Brunnermeier, M.K., James, H., Landau, J.P., 2016. The Euro and the Battle of Ideas. Princeton University Press.
Clarida, R., 2020. The Federal Reserve's New Monetary Policy Framework: A Robust Evolution. At the Peterson Institute for International Economics, Washington, D.C. (via webcast).
Coibion, O., Gorodnichenko, Y., 2011. Monetary Policy, Trend Inflation, and the Great Moderation: An Alternative Interpretation. American Economic Review 101 (1), 341–370.
Coibion, O., Gorodnichenko, Y., 2012. Why Are Target Interest Rate Changes so Persistent. American Economic Journal: Macroeconomics 4 (4), 126–162.
Cook, S., 2014. Forecast Encompassing Tests as a Means of Forecast Comparison The Economics Network.
Correa, R., Garud, K., Londono, J.M., Mislang, N., 2021. Sentiment in Central Banks' Financial Stability Reports. Review of Finance 25, 85–120.
Dincer, N., Eichengreen, B., Geraats, P., 2019. Transparency of Monetary Policy in the Postcrisis World. in: Mayer, D.G., Siklos, P.L., and Sturm, J.E. (Ebs.), The Oxford Handbook of the Economics of Central Banking. Oxford University Press.
Dybowski, P.T., Kempa, B., 2020. The European Central Bank's Monetary Pillar after the Financial Crisis. Journal of Banking and Finance 121, 105965.
Ehrmann, M., Tietz, R., Visser, B., 2021. Voting Right Rotation, Behavior of Committee Members and Financial Market Reactions; Evidence from the U.S. Federal Open Market Committee. Working Paper. Manuscript from 14 March 2022.
European Central Bank, 2019. Speeches dataset. Retrieved from: https://www.ecb.europa.eu/press/key/html/downloads.en.html. Press Release. Last Accessed: February 18, 2021.
European Central Bank, 2021a. ECB's Governing Council Approves its New Monetary Policy Strategy. Press Release. Last Accessed: July 12, 2021.
European Central Bank, 2021b. The ECB's Price Stability Framework: Past Experience, and Current and Future Challenges. Occasitional Paper Series No. 269.
Federal Reserve System, 2016. Speeches of Federal Reserve Officials. Archive. https://www.federalreserve.gov/newsevents/speech/speeches-archive.htm (Last Accessed: July 12, 2021).
Federal Reserve System, 2020. Review of Monetary Policy Strategy, Tools, and Communications. Information. Last Accessed: July 12, 2021.
Federal Reserve System, 2021. Speeches of Federal Reserve Officials. https://www.federalreserve.gov/newsevents/speeches.htm (Last Accessed: July 12, 2021).
Feldkircher, M., Hofmarcher, P., Siklos, P., 2021. What do central banks talk about? A European perspective on central bank communication. Focus on European Economic Integration Q2, 61–81.
Ferrara, F.M., 2020. The Battle of Ideas on the Euro Crisis: Evidence from ECB Inter-Meeting Speeches. Journal of European Public Policy 27, 1463–1486.
Ferrara, F.M., Angino, S., 2021. Does Clarity Make Central Banks More Engaging? Lessons From ECB Communications. European Journal of Political Economy. In Press.
Ferrara, F.M., Masciandao, D., Moschella, M., Romelli, D., 2021. Political Voice on Monetary Policy: Evidence from the Parliamentary Hearings of the European Central Bank. European Journal of Political Economy. In Press.
Fortes, R., Guenedal, T.L., 2020. Tracking ECB's Communication: Perspectives and Implications for Financial Markets. Working Paper.
Hansen, S., McMahon, M., Prat, A., 2018. Transparency and Deliberation within the FOMC: A Computational Linguistics Approach. Quart. J. Econ. 133, 801–870.
Hartmann, P., Smets, F., 2018. The European Central Bank's Monetary Policy during Its First 20 Years. Brookings Papers on Economic Activity, Fall, 1-146.
Krippner, L., 2013. Measuring the stance of monetary policy in zero lower bound environments. Economics Letters 118, 135–138.
Loughran, T., McDonald, B., 2011. When Is a Liability Not a Liability? Textual Analysis, Dictionaries, and 10-Ks. Journal of Finance 66 (1), 35–65.
Mimno, D., Talley, E., Leenders, M., Wallach, H.M., McCallum, A., 2011. Optimizing Semantic Coherence in Topic Models. Proceedings of the 2011 Conference on Empirical Methods in Natural Language Processing, 262–272.
Moschella, M., Pinto, L., 2019. Central Banks' Communication as Reputation Management: How the Fed Talks under Uncertainty. Public Admin. 97, 513–529.
Moschella, M., Pinto, L., Diodati, N.M., 2020. Let's Speak More? How the ECB Responds to Public Contestation. Journal of European Public Policy 23, 400–418.
Neuhierl, A., Weber, M., 2019. Monetary Policy Communication, Policy Slope, and the Stock Market. Journal of Monetary Economics 108 (C), 140–155.
Orphanides, A., 2019. Monetary Policy Strategy and its Communication. pp. 211–260. In: Federal Reserve Bank of Kansas City (Ebs.), Challenges for Monetary Policy.

Orphanides, A., 2021. The Year the Power of Central Bank Balance Sheets was Unleashed. pp. 341–356. in: English, B., Forbes, K., and Ubide, A. (Ebs.), Monetary Policy and Central Banking in the Covid Era. CEPR Press.
Paloviita, M., Haavio, M., Jalasjoki, P., Kilponen, J., Vänni, I., 2020. Reading between the Lines - Using Text Analysis to Estimate the Loss Function of the ECB. Bank of Finland Research Discussion Paper 12/2020.
Picault, M., Renault, T., 2017. Words are not all Created Equal: A New Measure of ECB Communication. Journal of International Money and Finance 79, 136–156.
Roberts, M.E., Stewart, B.M., Airoldi, E., 2016. A Model of Text for Experimentation in the Social Sciences. Journal of the American Statistical Association 111, 988–1003.
Roberts, M.E., Stewart, B.M., Tingley, D., 2019. stm: R Package for Structural Topic Models. J. Stat. Softw. 91.
Schonhardt-Bailey, C., Dann, C., Chapman, J., 2022. The Accountability Gap: Deliberation on Monetary Policy in Britain and America during the Financial Crisis. European Journal of Political Economy. In Press.
Shapiro, A.H., Wilson, D., 2021. Taking the Fed at its Word: A New Approach to Estimating Central Bank Objectives using Text Analysis. Review of Economic Studies.
Summers, L.H., 2014. U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound. Business Economics 49, 65–73.
Taylor, J.B., 1993. Discretion versus Policy Rules in Practice. Carnegie-Rochester Conference Series on Public Poliy 39 (1), 195–214.
Woodford, M., 2003. Interest & Prices. Princeton University Press.
World Health Organization, 2020. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - 11 March 2020. Speech. Https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020, Last Access: 1 June 2021.
Wu, J.C., Xia, F.D., 2016. Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. Journal of Money, Credit, and Banking 48 (2–3), 253–291.
Zeileis, A., Kleiner, C., Krämer, W., Hornik, K., 2003. Testing and Dating Structural Changes in Practice. Comput. Stat. Data Anal. 44, 109–123.